

Draft Technical Memorandum

To: Columbia River CWR Project Team

From: John Palmer and Dru Keenan

Date: November 2, 2017

Subject: Screening Approach to Identify Tributaries that Currently Provide CWR in the Lower Columbia River

This memo describes the approach to identify tributaries to the Lower Columbia River that currently provide cold water refuge (CWR) that could be used by salmon and steelhead. There are 191 tributaries to the Lower Columbia River in the National Hydrologic Database (NHD). The modeled August mean temperatures for each of the 191 tributaries and the Columbia River near the confluence of each tributary were obtained from the NorWeST project and are presented in Appendix 1. Appendix 1 also includes the difference between the August mean temperature of the tributary and the August mean temperature of the Columbia River and the August mean flow of each tributary using the Extended Unit Runoff Method model in NHD. To identify current tributaries providing CWR, EPA applied four screens using the database in Appendix 1.

First, EPA screened for those tributaries that have an August mean temperature that is at least 2°C colder than the Columbia River and have an August mean flow greater than 10 cfs, excluding sloughs/bays. Tributaries meeting these criteria are listed in Table 1. EPA used 2°C temperature difference since that is the temperature difference needed to meet the State of Oregon's definition of the cold water refuge. The EPA used 10 cfs as an approximate minimum flow needed to form a cool water plume in the Columbia River, which would attract salmon and steelhead use. Sloughs/bays were excluded (five in the database that are identified as being 2°C or more colder than the Columbia River) because the model for sloughs/bays actually reflects the temperature of an inflowing tributary a significant distance away from the Columbia River.

Second, EPA selected those tributaries with an August mean temperature of 16°C or cooler and a flow between 7 and 10 cfs. Tributaries meeting these criteria are listed in Table 2. EPA added this screen because tributaries that are this cold, even with lower flows, have the potential to form a small cool water plume in the Columbia River that salmon and steelhead could access. Those tributaries with flows less than 7 cfs were judged to be too small to have a cool plume of significance.

Table 1 – Tributaries at Least 2°C Cooler Than the Columbia River with Flow Greater Than 10 cfs

Code	Tributary Name	River Mile	Mainstem Temp	Tributary Temp	Temperature Difference	Tributary Mean Flow
18	Grays River*	19.6	21.10	15.94	-5.16	64
28	Skamokawa Creek	30.9	21.10	16.16	-4.94	23
37	Clatskanie River*	45.0	21.10	17.04	-4.06	33
38	Mill Creek	51.3	20.99	14.50	-6.49	10
40	Abernethy Creek	51.7	20.90	15.70	-5.20	10
49	Cowlitz River	65.2	20.75	15.95	-4.80	3634
52	Kalama River	70.5	20.92	16.32	-4.60	264
63	Lewis River	84.4	21.35	16.56	-4.79	1417
77	Sandy River	117.1	21.50	18.78	-2.72	469
78	Washougal River	117.6	21.50	19.17	-2.33	136
85	Wahkeena Creek	131.7	21.03	13.64	-7.39	15
86	Oneonta Creek	134.3	21.13	13.12	-8.01	29
88	Woodward Creek	137.7	21.25	16.82	-4.43	34
89	McCord Creek	138.8	21.29	11.74	-9.55	15
91	Tanner Creek	140.9	21.24	11.66	-9.58	38
92	Eagle Creek	142.7	20.91	15.07	-5.84	72
94	Rock Creek	146.6	20.99	17.42	-3.57	47
96	Herman Creek	147.5	20.99	12.02	-8.97	45
100	Wind River	151.1	20.95	14.46	-6.49	293
105	Lindsey Creek*	155.3	20.92	13.88	-7.04	11
112	Little White Salmon River	158.7	20.90	13.34	-7.56	88
115	White Salmon River	164.9	21.10	15.74	-5.36	692
116	Hood River	165.7	21.30	15.53	-5.77	374
125	Klickitat River	176.8	21.20	16.37	-4.83	852
129	Fifteenmile Creek*	188.9	21.40	19.15	-2.25	37
135	Deschutes River	200.8	21.50	19.18	-2.32	3447

Table 2 – Tributaries with August Mean of 16°C or Less and Flow Between 7 - 10 cfs

Code	Tributary Name	River Mile	Mainstem Temp	Tributary Temp	Temperature Difference	Tributary Mean Flow
20	Crooked Creek*	20.1	21.10	15.48	-5.62	7
41	Germany Creek	53.6	20.43	15.36	-5.07	8
83	Bridal Veil Creek	128.9	20.93	11.66	-9.27	7
90	Moffett Creek	139.8	21.28	12.82	-8.46	9
102	Gorton Creek*	152.1	20.95	12.65	-8.30	8

Third, the EPA selected tributaries with flows greater than 10 cfs and at times have temperatures at least 2°C colder than the Columbia River during mid-July through mid-September when it typically exceeds 20°C. Tributaries meeting these criteria are listed in Table 3. These tributaries were included because they provide CWR refuge for some time periods even though the tributary is not 2°C or colder than the Columbia River based on August mean temperatures. All tributaries with monitoring data were reviewed for this screen assessment (data included in Peter Leinenbach's February 17, 2017 Memorandum).

Table 3 – Tributaries with Flow Greater Than 10 cfs and with Times Temperatures are at Least 2°C Cooler Than the Columbia River

Code	Tributary Name	River Mile	Mainstem Temp	Tributary Temp	Temperature Difference	Tributary Mean Flow
147	John Day River*	215.5	21.57	20.66	-0.91	245
167	Willow Creek*	249.4	21.20	20.11	-1.09	15
176	Umatilla River	284.7	20.82	20.81	-0.01	384

Finally, the EPA reviewed maps and available information for each of the tributaries in Tables 1, 2, and 3 and removed tributaries if it was determined that migrating adult salmon and steelhead would have limited to no access to the cooler water or would be unlikely to detect it when migrating up the Columbia mainstem. Eight tributaries denoted with an “*” in Tables 1, 2, and 3 were removed for this reason. Grays River and Crooked Creek were removed because they enter the very large Columbia River estuary on the north end away from the likely migratory route for most salmon and steelhead traveling upriver. In addition, these two tributaries are only a short distance from the cold ocean. The Clatskanie River was removed because the river enters a long low velocity channel before it connects with the main channel of the Columbia River. The Clatskanie River temperatures reflected in Table 1 are from an upstream monitoring location and the channel likely warms prior to reaching the mainstem. Gordon and Lindsay Creeks were removed because they enter pond areas adjacent to the Columbia River formed by infill for the railroad tracks. These creeks have small flows and the ponds likely warm up in the summer and are only accessible to fish via a pipe under the railroad tracks. Fifteen-mile Creek was removed because field observation indicated a flow less than was indicated in Table 1 and the salmon and steelhead would need to swim through a back channel of the Columbia River to find the very small cool water where the tributary enters into the channel. Monitored temperature data for the Fifteen-mile creek is also warmer than the modelled temperature reflected in Table 1. Willow Creek was removed because it enters into a backwater bay area of the Columbia River. Thus, the small amount of cooler water from this fairly low flow creek would not be detectable nor readily accessible to migrating salmon and steelhead in the mainstem. John Day River was removed because the River enters a very long arm that is part of the John Day Reservoir. Thus, to the extent the John Day River is cooler than the Columbia River (in September only), the cooler water is not detectable nor readily accessible to migration salmon and steelhead in the mainstem.

The tributaries in Tables 1, 2, and 3 minus the eight tributaries removed due accessibility limitations are listed in Table 4. These 26 tributaries represent the tributaries that currently provide cold water refuge in the Lower Columbia based on EPA screening approach describe in this memo.

Table 4 – Tributaries Currently Providing CWR in the Lower Columbia River

Code	Tributary Name	River Mile	Mainstem Temp	Tributary Temp	Temperature Difference	Tributary Mean Flow
28	Skamokawa Creek	30.9	21.10	16.16	-4.94	23
38	Mill Creek	51.3	20.99	14.50	-6.49	10
40	Abernethy Creek	51.7	20.90	15.70	-5.20	10
41	Germany Creek	53.6	20.43	15.36	-5.07	8
49	Cowlitz River	65.2	20.75	15.95	-4.80	3634
52	Kalama River	70.5	20.92	16.32	-4.60	264
63	Lewis River	84.4	21.35	16.56	-4.79	1417
77	Sandy River	117.1	21.50	18.78	-2.72	469
78	Washougal River	117.6	21.50	19.17	-2.33	136
83	Bridal Veil Creek	128.9	20.93	11.66	-9.27	7
85	Wahkeena Creek	131.7	21.03	13.64	-7.39	15
86	Oneonta Creek	134.3	21.13	13.12	-8.01	29
88	Woodward Creek	137.7	21.25	16.82	-4.43	34
89	McCord Creek	138.8	21.29	11.74	-9.55	15
90	Moffett Creek	139.8	21.28	12.82	-8.46	9
91	Tanner Creek	140.9	21.24	11.66	-9.58	38
92	Eagle Creek	142.7	20.91	15.07	-5.84	72
94	Rock Creek	146.6	20.99	17.42	-3.57	47
96	Herman Creek	147.5	20.99	12.02	-8.97	45
100	Wind River	151.1	20.95	14.46	-6.49	293
112	Little White Salmon River	158.7	20.90	13.34	-7.56	88
115	White Salmon River	164.9	21.10	15.74	-5.36	692
116	Hood River	165.7	21.30	15.53	-5.77	374
125	Klickitat River	176.8	21.20	16.37	-4.83	852
135	Deschutes River	200.8	21.50	19.18	-2.32	3447
176	Umatilla River	284.7	20.82	20.81	-0.01	384

Appendix 1

191 Lower Columbia River Tributaries (Sorted by August Mean Flow)

Code	Tributary Name	River Mile	Mainstem Temp	Tributary Temp	Temperature Difference	Tributary Mean Flow
70	Willamette River	98.18	21.77	22.01	0.24	8591.46
49	Cowlitz River	65.24	20.75	15.95	-4.80	3634.48
135	Deschutes River	200.83	21.50	19.18	-2.32	3446.5
63	Lewis River	84.44	21.35	16.56	-4.79	1417.01
125	Klickitat River	176.84	21.20	16.37	-4.83	852.218
115	White Salmon River	164.91	21.10	15.74	-5.36	692.4
77	Sandy River	117.13	21.50	18.78	-2.72	469.206
176	Umatilla River	284.65	20.82	20.81	-0.01	384.059
116	Hood River	165.66	21.30	15.53	-5.77	374.05
100	Wind River	151.12	20.95	14.46	-6.49	293.338
52	Kalama River	70.53	20.92	16.32	-4.60	264.032
147	John Day River	215.49	21.57	20.66	-0.91	245.19
78	Washougal River	117.63	21.50	19.17	-2.33	136.446
5	Youngs Bay	8.39	21.10	16.73	-4.37	99.458
112	Little White Salmon River	158.7	20.90	13.34	-7.56	87.907
92	Eagle Creek	142.73	20.91	15.07	-5.84	71.901
18	Grays River	19.64	21.10	15.94	-5.16	64.42
11	Cathlamet Bay	15.53	21.10	17.08	-4.02	62.742
94	Rock Creek	146.58	20.99	17.42	-3.57	47.42
96	Herman Creek	147.45	20.99	12.02	-8.97	45.488
91	Tanner Creek	140.86	21.24	11.66	-9.58	37.721
129	Fifteenmile Creek	188.9	21.40	19.15	-2.25	36.518
88	Woodward Creek	137.7	21.25	16.82	-4.43	34.117
37	Clatskanie River	44.99	21.10	17.04	-4.06	32.976
62	Multnomah Channel	83.57	21.32	21.80	0.48	30
86	Oneonta Creek	134.34	21.13	13.12	-8.01	29.24
30	Elochoman Slough	33.31	21.10	15.37	-5.73	27.981
65	Lake River	84.57	21.35	19.76	-1.59	25.484
188	Walla Walla River	309.38	20.80	22.09	1.29	23.673
28	Skamokawa Creek	30.94	21.10	16.16	-4.94	22.705
85	Wahkeena Creek	131.73	21.03	13.64	-7.39	15.227
89	McCord Creek	138.81	21.29	11.74	-9.55	14.688
167	Willow Creek	249.36	21.20	20.11	-1.09	14.667
42	Coal Creek Slough	54	20.41	17.12	-3.29	11.65

105	Lindsey Creek	155.34	20.92	13.88	-7.04	11.152
38	Mill Creek	51.33	20.99	14.50	-6.49	10.348
40	Abernethy Creek	51.7	20.90	15.70	-5.20	10.295
36	Westport Slough	40.51	21.10	16.07	-5.03	10.137
90	Moffett Creek	139.81	21.28	12.82	-8.46	8.949
153	Rock Creek	226.18	21.46	20.03	-1.43	8.713
41	Germany Creek	53.62	20.43	15.36	-5.07	8.459
2	Chinook River	2.67	21.10	16.72	-4.38	7.822
102	Gorton Creek	152.05	20.95	12.65	-8.30	7.541
20	Crooked Creek	20.13	21.10	15.48	-5.62	7.464
83	Bridal Veil Creek	128.93	20.93	11.66	-9.27	7.412
17	Deep River	19.08	21.10	18.21	-2.89	7.137
54	Tide Creek	71.21	20.94	17.96	-2.98	6.807
4	Skipanon River	8.33	21.10	18.98	-2.12	5.264
87	Duncan Creek	136.76	21.22	14.72	-6.50	5.07
93	Ruckel Creek	143.35	20.93	12.64	-8.29	4.887
1	Wallacut River	0.99	21.10	16.07	-5.03	4.729
170	Alder Creek	254.2	21.15	18.96	-2.19	4.577
123	Major Creek	173.86	21.23	18.90	-2.33	4.421
25	Jim Crow Creek	26.16	21.10	14.59	-6.51	4.291
107	Warren Creek	155.78	20.92	12.11	-8.81	3.921
10	Unnamed Trib - 6	11.87	21.10	15.21	-5.89	3.818
174	Glade Creek	267.62	21.00	19.20	-1.80	3.788
12	Unnamed Trib - 7	16.28	21.10	14.93	-6.17	3.608
15	Sisson Creek	18.21	21.10	23.14	2.04	3.422
53	Goble Creek	71.15	20.94	15.91	-5.03	3.292
81	Latourell Creek	124.96	20.86	16.40	-4.46	3.232
6	Unnamed Trib - 2	9.57	21.10	15.05	-6.05	3.181
57	Burris Creek	76.8	21.11	18.36	-2.75	3.023
32	Unnamed Trib - 17	34.49	21.10	21.48	0.38	2.754
64	Gee Creek	84.51	21.35	18.97	-2.38	2.688
111	Dog Creek	157.52	20.90	13.36	-7.54	2.426
184	Unnamed Trib - 84	300.74	20.80	19.76	-1.04	2.205
166	Pine Creek	246.13	21.24	18.97	-2.27	2.127
119	Rock Creek	171.37	21.25	17.83	-3.42	2.107
80	Lawton Creek	124.77	20.88	16.38	-4.50	2.086
82	Young Creek	127.01	20.85	12.90	-7.95	1.995
44	Green Creek	55.61	20.46	15.42	-5.04	1.981
120	Mosier Creek	171.44	21.25	18.75	-2.50	1.969
103	Harphan Creek	152.92	20.94	13.38	-7.56	1.914
97	Nelson Creek	148.13	20.98	14.24	-6.74	1.869

164	Wood Creek	239.97	21.31	18.63	-2.68	1.822
101	Grays Creek	151.61	20.95	11.61	-9.34	1.784
3	Unnamed Trib - 1	3.6	21.10	17.79	-3.31	1.744
7	Unnamed Trib - 3	10.69	21.10	14.68	-6.42	1.725
99	Carson Creek	150.12	20.96	14.41	-6.55	1.64
110	Viento Creek	157.21	20.90	13.23	-7.67	1.611
27	Unnamed Trib - 16	28.15	21.10	16.09	-5.01	1.61
55	Schoolhouse Creek	75	21.05	16.03	-5.02	1.608
142	Unnamed Trib - 52	205.67	21.54	18.90	-2.64	1.574
14	Unnamed Trib - 8	16.9	21.10	14.17	-6.93	1.483
39	Bradbury Slough	51.39	20.98	16.73	-4.25	1.379
19	Unnamed Trib - 10	19.7	21.10	19.28	-1.82	1.335
8	Unnamed Trib - 4	11.37	21.10	14.11	-6.99	1.308
16	Unnamed Trib - 9	18.27	21.10	14.86	-6.24	1.274
35	Driscoll Slough	39.83	21.10	14.68	-6.42	1.252
45	Unnamed Trib - 19	57.6	20.52	19.08	-1.44	1.248
114	Phelps Creek	162.8	20.90	16.25	-4.65	1.232
75	Unnamed Trib - 33	112.34	21.50	16.93	-4.57	1.193
127	Chenoweth Creek	183.62	21.34	19.69	-1.65	1.148
95	Kanaka Creek	147.39	20.99	14.31	-6.68	1.113
51	Unnamed Trib - 21	68.1	20.84	17.08	-3.76	1.009
136	Unnamed Trib - 46	202.5	21.51	19.03	-2.48	1.005
104	Summit Creek	154.54	20.93	11.11	-9.82	0.967
48	Fox Creek	65.06	20.75	15.48	-5.27	0.957
13	Frank Born Creek	16.71	21.10	14.37	-6.73	0.954
84	Coopey Creek	129.31	20.94	12.61	-8.33	0.948
9	Unnamed Trib - 5	11.62	21.10	14.70	-6.40	0.941
21	Unnamed Trib - 11	20.44	21.10	23.91	2.81	0.94
98	Unnamed Trib - 36	149.13	20.97	14.26	-6.71	0.914
109	Starvation Creek	156.15	20.91	11.81	-9.10	0.892
61	Unnamed Trib - 24	81.34	21.25	19.21	-2.04	0.875
117	Jewett Creek	166.84	21.29	15.39	-5.90	0.868
22	Unnamed Trib - 12	22.06	21.10	23.91	2.81	0.807
122	Catherine Creek	173.55	21.23	17.48	-3.75	0.792
72	Unnamed Trib - 30	107	21.50	20.83	-0.67	0.777
23	Unnamed Trib - 13	22.56	21.10	23.91	2.81	0.767
175	Unnamed Trib - 76	282.35	20.84	19.36	-1.48	0.765
26	Unnamed Trib - 15	26.22	21.10	23.91	2.81	0.756
79	Unnamed Trib - 35	119.92	21.36	19.07	-2.29	0.737
128	Threemile Creek	187.53	21.40	17.06	-4.34	0.723
182	Unnamed Trib - 82	296.95	20.80	19.35	-1.45	0.676

60	McBride Creek	80.03	21.21	16.81	-4.40	0.582
56	Bybee Creek	76.06	21.09	15.94	-5.15	0.528
43	Flume Creek	55.3	20.45	15.56	-4.89	0.522
24	Unnamed Trib - 14	23.3	21.10	23.91	2.81	0.504
159	Chapman Creek	233.64	21.38	18.13	-3.25	0.491
29	Ellison Slough	33.24	21.10	15.15	-5.95	0.444
33	Unnamed Trib - 18	35.29	21.10	15.81	-5.29	0.439
161	Unnamed Trib - 68	235	21.36	18.55	-2.81	0.435
113	Perham Creek	158.82	20.90	12.79	-8.11	0.382
69	Unnamed Trib - 28	93.39	21.62	19.20	-2.42	0.374
146	Unnamed Trib - 56	210.52	21.58	18.60	-2.98	0.356
108	Cabin Creek	156.09	20.91	11.68	-9.23	0.344
47	Nice Creek	64.81	20.74	15.07	-5.67	0.315
121	Unnamed Trib - 39	172.24	21.24	16.50	-4.74	0.313
130	Eightmile Creek	192.13	21.42	17.28	-4.14	0.301
66	Unnamed Trib - 25	89.42	21.50	22.06	0.56	0.267
76	Unnamed Trib - 34	113.65	21.50	15.78	-5.72	0.265
190	Unnamed Trib - 89	310.5	20.80	19.39	-1.41	0.258
67	Unnamed Trib - 26	91.28	21.56	19.22	-2.34	0.254
163	China Ditch	238.23	21.33	18.92	-2.41	0.25
31	Pete Anders Slough	33.49	21.10	15.67	-5.43	0.206
187	Unnamed Trib - 87	306.21	20.80	19.75	-1.05	0.205
73	Unnamed Trib - 31	108.86	21.50	20.09	-1.41	0.19
50	Owl Creek	65.99	20.78	15.28	-5.50	0.19
106	Unnamed Trib - 37	155.72	20.92	10.98	-9.94	0.176
156	Unnamed Trib - 64	230.22	21.41	18.78	-2.63	0.173
124	Unnamed Trib - 40	174.29	21.22	17.25	-3.97	0.161
59	Unnamed Trib - 23	79.04	21.18	20.57	-0.61	0.155
118	Unnamed Trib - 38	168.33	21.27	14.88	-6.39	0.153
74	Unnamed Trib - 32	111.78	21.50	17.70	-3.80	0.149
186	Unnamed Trib - 86	302.92	20.80	19.78	-1.02	0.146
162	Unnamed Trib - 69	236.74	21.34	18.84	-2.50	0.142
143	Unnamed Trib - 53	207.48	21.55	18.43	-3.12	0.139
160	Unnamed Trib - 67	233.7	21.38	18.30	-3.08	0.125
133	Unnamed Trib - 44	194.49	21.44	17.47	-3.97	0.093
149	Unnamed Trib - 58	221.46	21.51	18.47	-3.04	0.091
126	Unnamed Trib - 41	177.84	21.21	15.97	-5.24	0.082
131	Unnamed Trib - 42	192.81	21.43	17.40	-4.03	0.073
148	Unnamed Trib - 57	220.46	21.52	17.88	-3.64	0.061
145	Unnamed Trib - 55	210.15	21.58	17.77	-3.81	0.058
68	Unnamed Trib - 27	91.4	21.56	19.50	-2.06	0.058

177	Unnamed Trib - 77	289.99	20.80	18.86	-1.94	0.055
58	Unnamed Trib - 22	77.3	21.13	22.52	1.39	0.051
185	Unnamed Trib - 85	302.42	20.80	18.09	-2.71	0.049
137	Unnamed Trib - 47	203.25	21.52	15.56	-5.96	0.049
189	Unnamed Trib - 88	309.44	20.80	21.44	0.64	0.048
139	Unnamed Trib - 49	204.68	21.53	17.30	-4.23	0.034
34	Grove Slough	36.72	21.10	16.83	-4.27	0.034
183	Unnamed Trib - 83	300.43	20.80	19.36	-1.44	0.031
178	Unnamed Trib - 78	290.49	20.80	19.07	-1.73	0.031
132	Unnamed Trib - 43	193.18	21.43	18.60	-2.83	0.03
141	Unnamed Trib - 51	205.49	21.54	17.87	-3.67	0.025
150	Unnamed Trib - 59	222.64	21.50	18.35	-3.15	0.022
144	Unnamed Trib - 54	209.03	21.57	18.00	-3.57	0.022
46	Unnamed Trib - 20	58.6	20.55	21.83	1.28	0.022
191	Unnamed Trib - 90	317.21	20.80	23.10	2.30	0.02
138	Unnamed Trib - 48	204.37	21.53	16.44	-5.09	0.02
181	Unnamed Trib - 81	295.03	20.80	19.71	-1.09	0.019
71	Unnamed Trib - 29	100.72	21.85	23.91	2.06	0.016
165	Unnamed Trib - 70	242.52	21.28	20.17	-1.11	0.013
134	Unnamed Trib - 45	196.48	21.46	18.01	-3.45	0.005
180	Unnamed Trib - 80	294.96	20.80	18.76	-2.04	0.001
179	Unnamed Trib - 79	290.8	20.80	23.94	3.14	0.001
173	Unnamed Trib - 75	261.91	21.07	19.27	-1.80	0.001
172	Unnamed Trib - 74	257.74	21.11	23.94	2.83	0.001
171	Unnamed Trib - 73	255.26	21.14	19.88	-1.26	0.001
169	Unnamed Trib - 72	253.77	21.16	19.93	-1.23	0.001
168	Unnamed Trib - 71	252.71	21.17	19.82	-1.35	0.001
158	Unnamed Trib - 66	231.65	21.40	17.86	-3.54	0.001
157	Unnamed Trib - 65	231.15	21.40	18.36	-3.04	0.001
155	Unnamed Trib - 63	229.66	21.42	18.70	-2.72	0.001
154	Unnamed Trib - 62	226.8	21.45	18.48	-2.97	0.001
152	Unnamed Trib - 61	225.06	21.47	18.72	-2.75	0.001
151	Unnamed Trib - 60	224.19	21.48	17.63	-3.85	0.001
140	Unnamed Trib - 50	204.74	21.53	23.94	2.41	0.001